



Armed Forces College of Medicine AFCM



Basal ganglia

Dr. Sarah Mahmoud

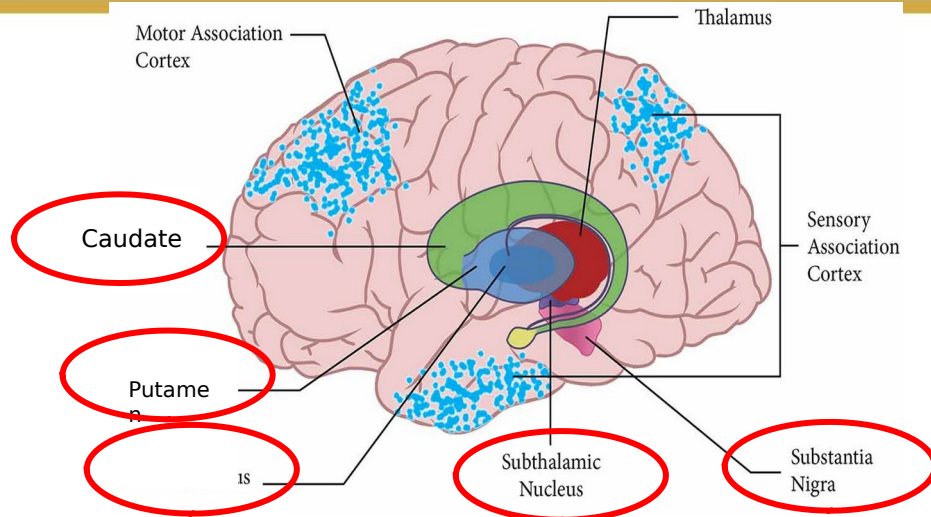
INTENDED LEARNING OBJECTIVES (ILO)



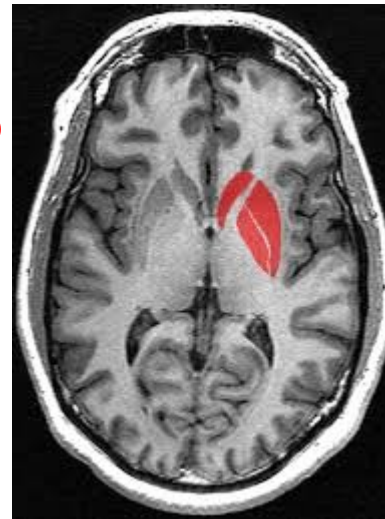
By the end of this lecture the student will be able to:

1. List the BG nuclei and the functionally associated centers.
2. List the functions of the basal ganglia.
3. Illustrate the neural structures involved in the control of movement, and highlight the role of the BG.
4. List the neurotransmitters that are released within the BG and their main functions.
5. Describe the role of the direct and indirect circuits in control of voluntary movement.
6. Illustrate the role of dopamine in both circuits.
7. Describe diseases caused by lesions in basal ganglia

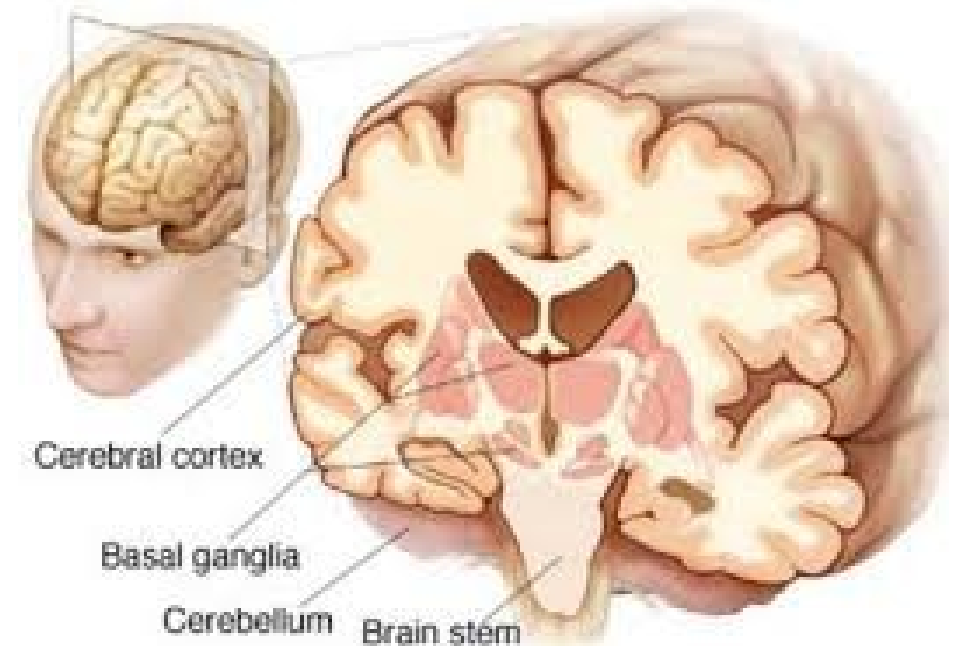
Anatomy of the Basal Ganglia



https://upload.wikimedia.org/wikipedia/commons/8/8c/Cortical_surface_with_an_overlay_of_the_basal_ganglia_and_thalamus.jpg



https://upload.wikimedia.org/wikipedia/commons/thumb/7/7d/Striatum_Structural_MRI.png/330px-Striatum_Structural_MRI.png



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Anatomy of the Basal Ganglia



- **Caudate nucleus.**

- **Putamen nucleus.**

**Corpus
Striatu**

- **Globus pallidus:**
(internal and external parts)

**m Lenticular
nucleus**

- **Subthalamic nucleus.**

- **Substantia nigra.**
(pars compacta & pars reticulata).

Neuronal Connections & neurotransmitters of the Basal Ganglia



(1) Internal Connections

striato-nigral
Nigro-striatal
striato-pallidal

interneurons of the striatum

Striatum $\xrightarrow{\text{(GABA) R}}$ SN
SN $\xleftarrow{\text{(Dopamine) C}}$ Striatum

Striatum $\xrightarrow{\text{GABA}}$ GP

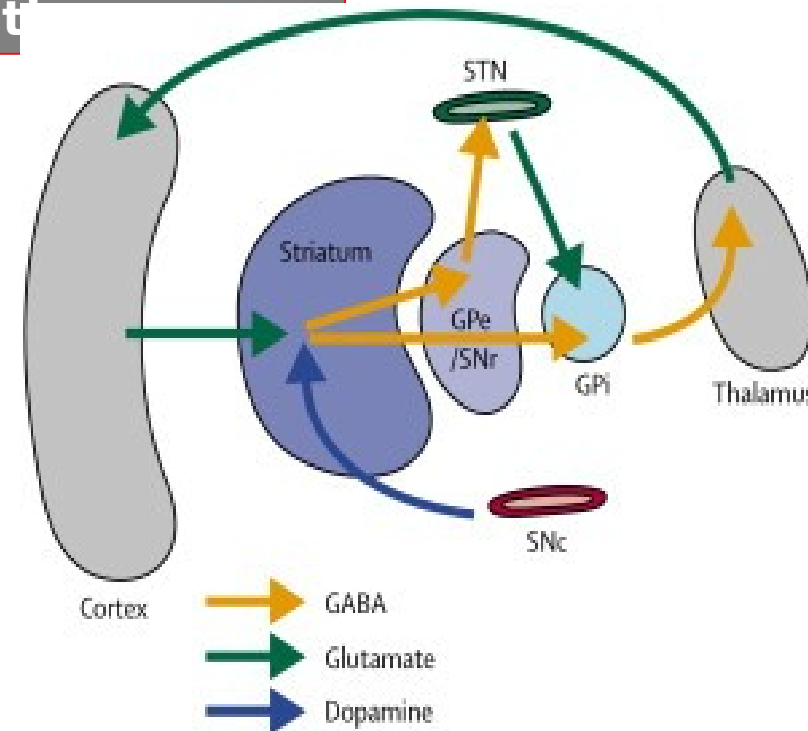
Acetyl choline

(2) Cortical Connections

Direct pathway
Indirect pathway

(3) Efferent Pathways

GP

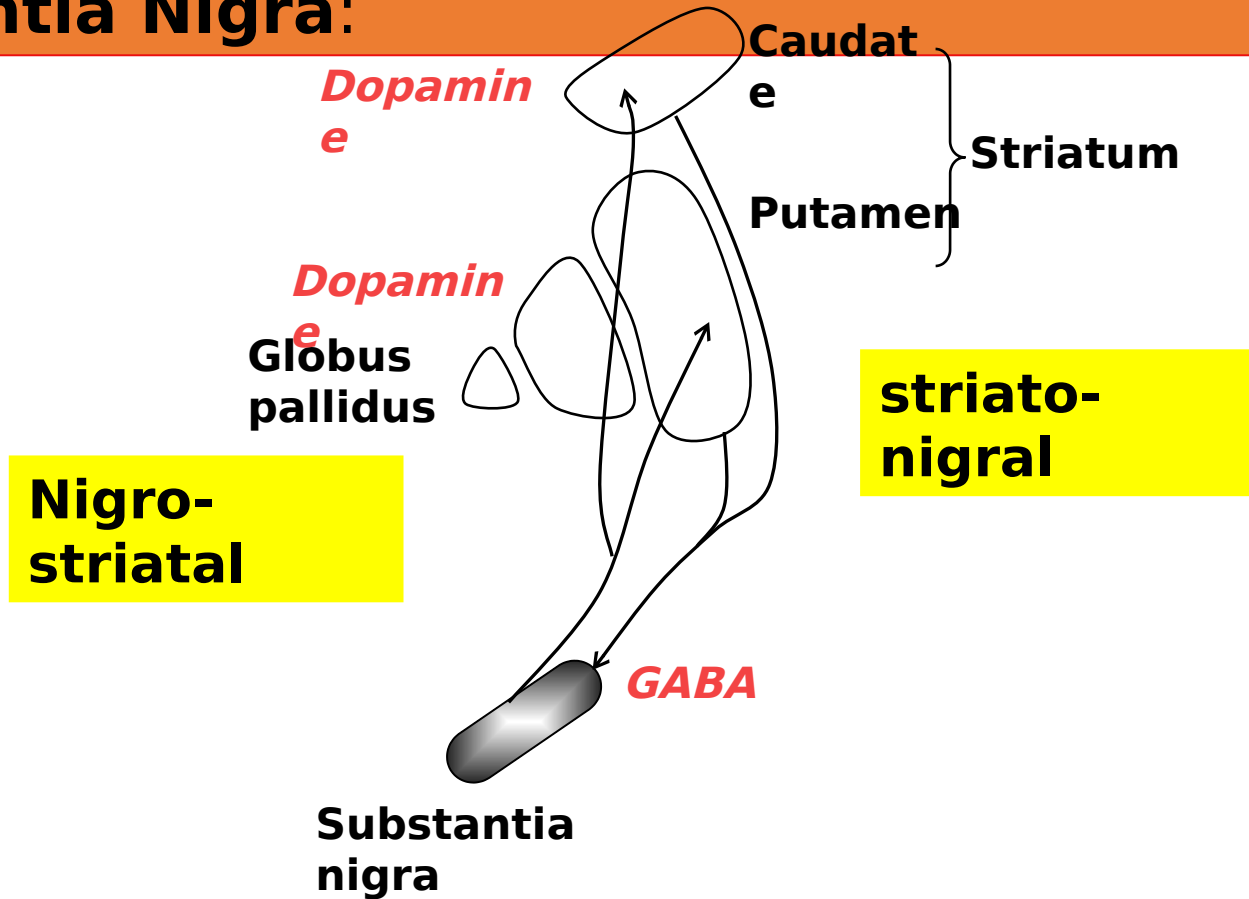


[https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(05\)17915-X/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(05)17915-X/fulltext)

Neuronal Connections & neurotransmitters of the Basal Ganglia

(1) Internal connections

Connection between Striatum and Substantia Nigra:



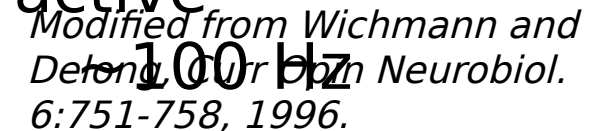
Neuronal Connections & neurotransmitters of the Basal Ganglia

(2) Cortical connections

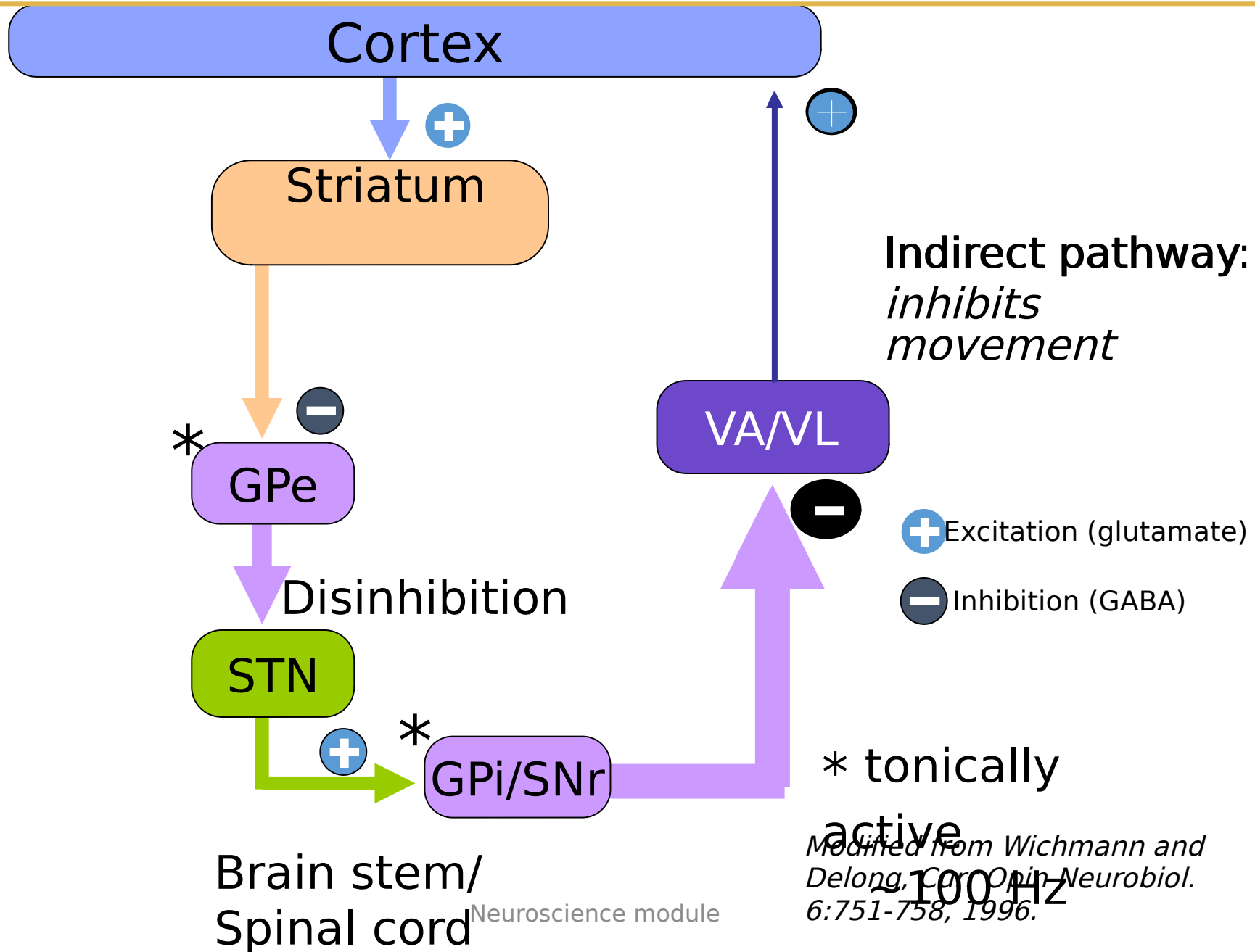
i. Direct pathway

ii. Indirect pathway

Direct pathway



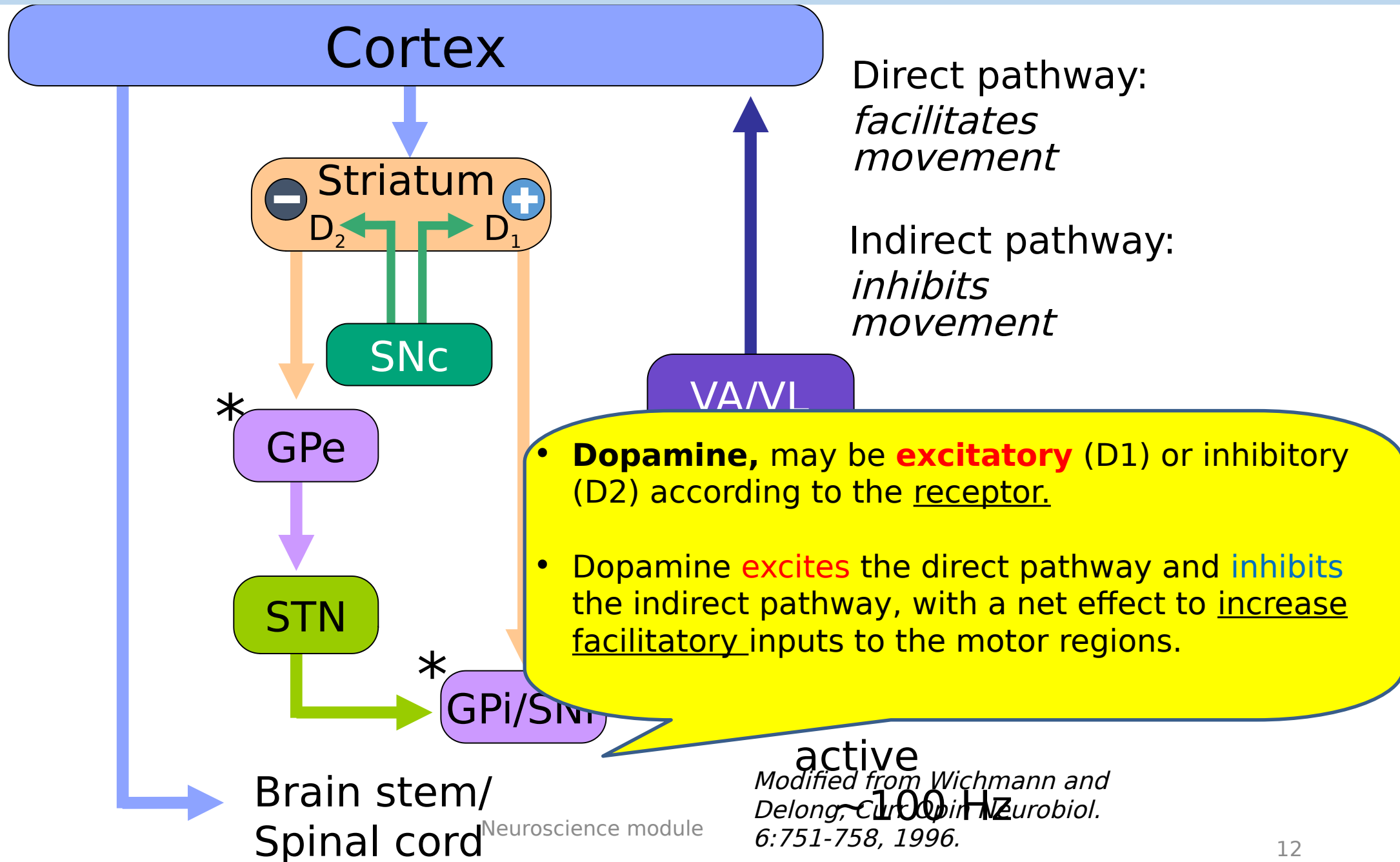
Indirect pathway



- Activation of the **direct** pathway **promotes** action.
- Activation of the **indirect** pathway **suppresses** action.

The Basal Ganglia **facilitates** the appropriate motor program for a task by exciting the cortex (through the Thalamus) using the **direct** pathway and **inhibits** other competing motor programs by inhibiting the cortex (again via the Thalamus) using the **indirect** pathway.

Role of dopamine in direct & indirect circuits

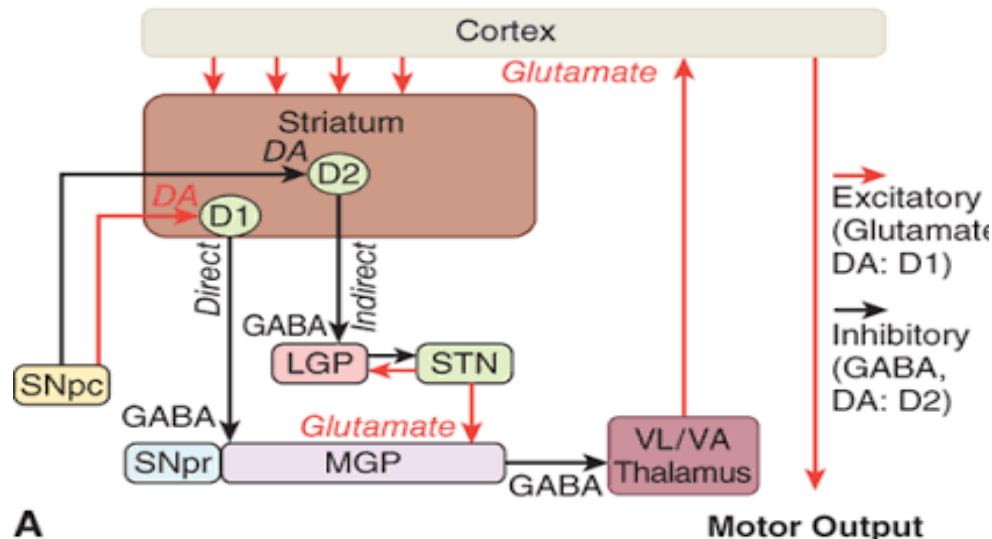


Neuronal Connections & neurotransmitters of the Basal Ganglia

(2) Cortical connections

i. Direct pathway

- The Cortex glutamate.....striatum.
- The Striatum . **GABA**.....the **internal segment of the Globus Pallidus**
- When the globus pallidus IS is inhibited they **cannot inhibit** the **Thalamus** rendering it free to fire and send **excitatory** input up to the Cortex which **facilitates movement**



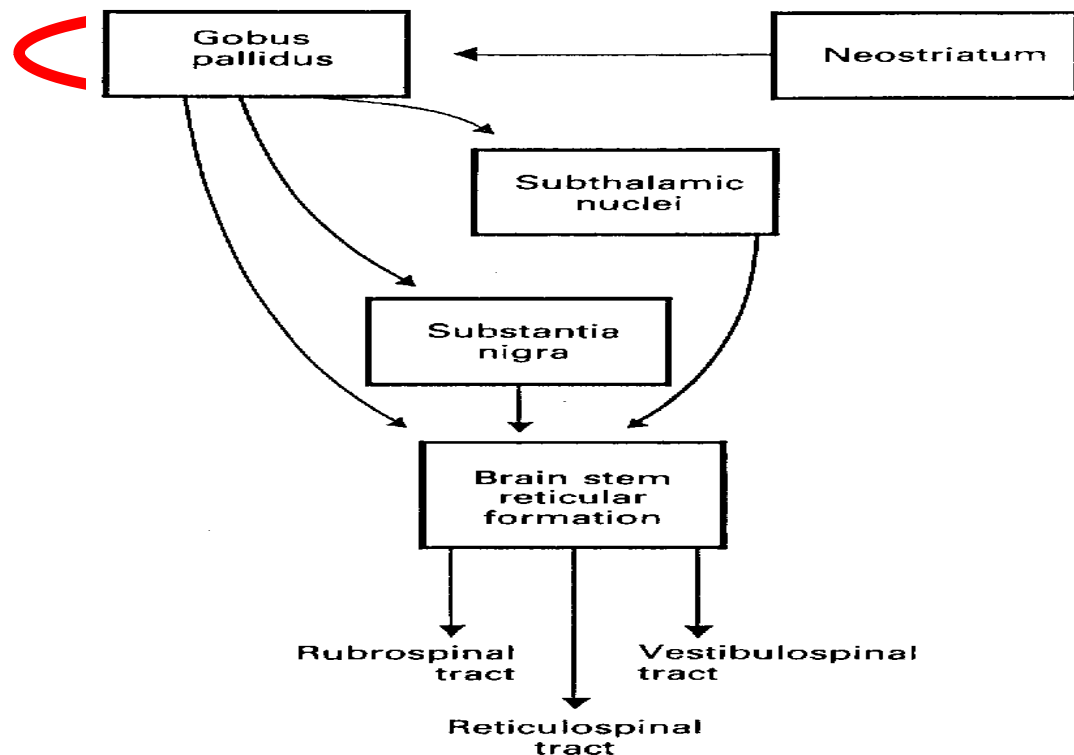
ii. Indirect pathway

- The Cortex glutamate.....striatum.
- The Striatum . **GABA**.....the **external segment of the Globus Pallidus**
- The Globus Pallidus external segment is *unable to inhibit the Subthalamic nucleus* leaving it free to fire.
- **The Subthalamic Nucleus** being uninhibited sends the only purely **excitatory input** within the Basal Ganglia pathways **to the Globus Pallidus internal segment**.
- Globus pallidus IS then **inhibits the VA and VL of the Thalamus** making it unable to send excitatory input to the Cortex and thus

Neuronal Connections & neurotransmitters of the Basal Ganglia



(3) Efferent Pathways



- **GPis** \square **GABA** \square **thalamus** (VL&VA nuclei) \square the cortex
- **GPes** \square **GABA** \square **subthalamus** and **brain stem nuclei** \square **RF** \square **extrapyramidal tracts** (reticulospinal, vestibulospinal and rubrospinal) \square **motor neurons of the spinal cord.**

<https://lh3.googleusercontent.com/elewxtk-OYDQefZLLVGX0S5-kWKUT-NCL7VwQXDzwlk-Qxs-fmzXnasOFrbqukwi>
CUQuBO0=s112

Functions of the Basal Ganglia



1- Cognitive control of sequences of motor patterns

Planning & programming

to “**select**” and “**plan**” the motor sequence to achieve a complex goal

Neurons of the BG discharge **before** movements begin.

Thought → voluntary action

2- Timing and scaling of movements

Determines

how large (= **spatial dimensions**) and **how fast** the movement will be



<https://www.euroformhealthcare.biz/medical-physiology/function-of-the-basal-ganglia-to-change-the-timing-and-to-scale-the-intensity-of-movements.html>

Functions of the Basal Ganglia

(Motor)

Execution of proper movement

putamen circuit

3- Execution of **subconscious learned** patterns of movement

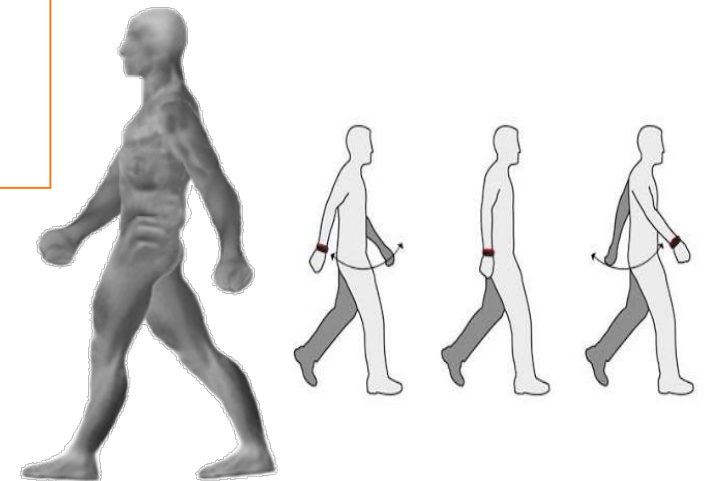
e.g. cutting with scissors
some aspects of vocalization

4- Initiation and regulation of the **gross associative movements** of the body

e.g. swinging of arms and facial expression



<https://www.livescience.com/44494-human-facial-expressions-compound-emotions.html>



https://en.wikipedia.org/wiki/Arm_swing_in_human_locomotion#/media/File:Walk-Cycle

Functions of the Basal Ganglia (Motor)

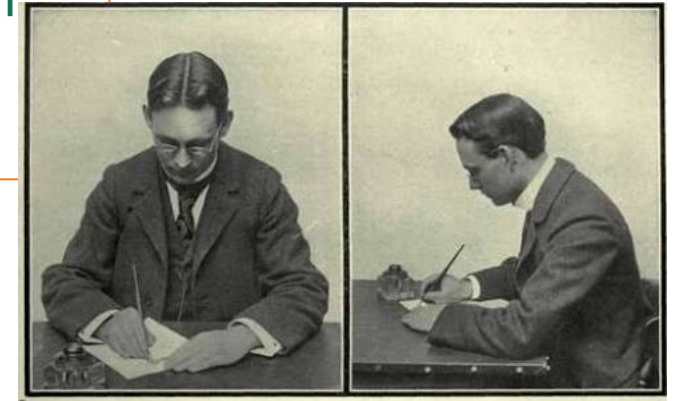


The globus pallidus

5- Responsible for the **posture** taken by the body to perform a particular voluntary movement

It locks the different parts of the body into a **specific position** so as to facilitate the fine movements of the hand.

6- Inhibitory to muscle tone (Damage → Rigidity)



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Diseases of the basal ganglia in human

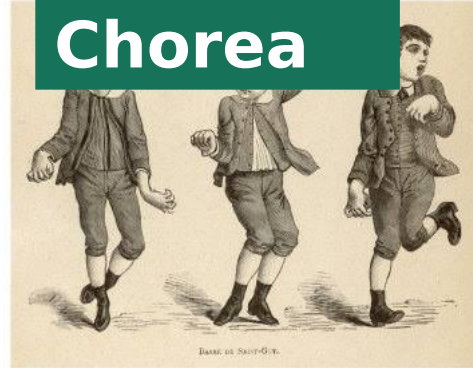


➤ Normal function of the BG is brought about by a **balance** between the various excitatory and inhibitory influences of the various transmitters.

➤ Diseases of the BG lead to 2 general types of disorders; **hyperkinetic** (1,2&3) and **hypokinetic** (akinesia & bradykinesia)

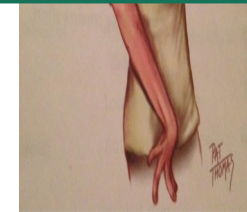
➤ BG dysfunction does **NOT** cause paralysis, sensory loss or ataxia but leads to **abnormal involuntary movement** & change in ms. Tone (hypertonia or hypotonia).

1- Chorea

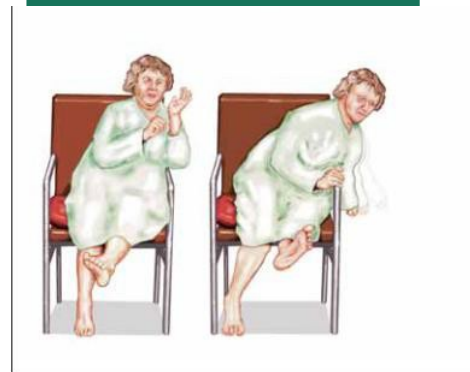


<http://absorbmedicine.blogspot.com/2013/11/causes-of-chorea-medical-mnemonics.html>

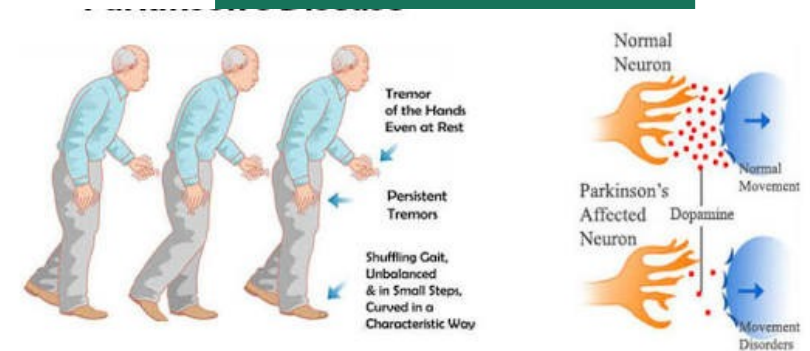
2- Athetosis



3-



4-



<https://studfiles.net/preview/396004/page:8/> <https://www.dailyhealthguard.com/treating-parkinsons-disease-new->

Diseases of the basal ganglia in human

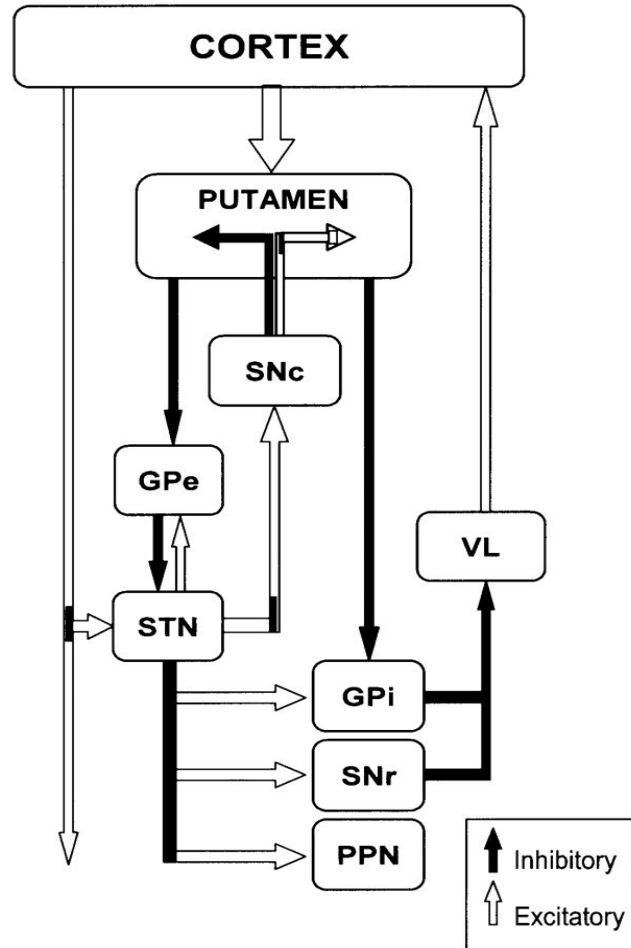


	1- Chorea	2- Athetosis	3- Ballism
Lesion	Caudate & putamen	Globus pallidus	Subthalamus
Cause / mechanism	Hereditary) <u>Huntington's chorea</u> (Or rheumatic (Swdenham's chorea) Damage of neostriatum (GABA) of the indirect pathway → removal of inhibition of substantia nigra and globus pallidus → allows spontaneous outbursts of their activity → abnormal movements	Wilson's disease where ceruloplasmin is low, there is chronic copper intoxication → degeneration of lenticular nucleus	Vascular lesion
Tone	--- (<u>pendular knee jerk</u>)	+++	+
Involuntary movement	Spontaneous, <u>rapid</u> , involuntary <u>dancing</u> movements	Continuous, <u>slow</u> <u>writhing</u> (<u>worm-like</u>) movements of the hands, arms, neck and face	<u>Rapid</u> , flailing, intense and violent

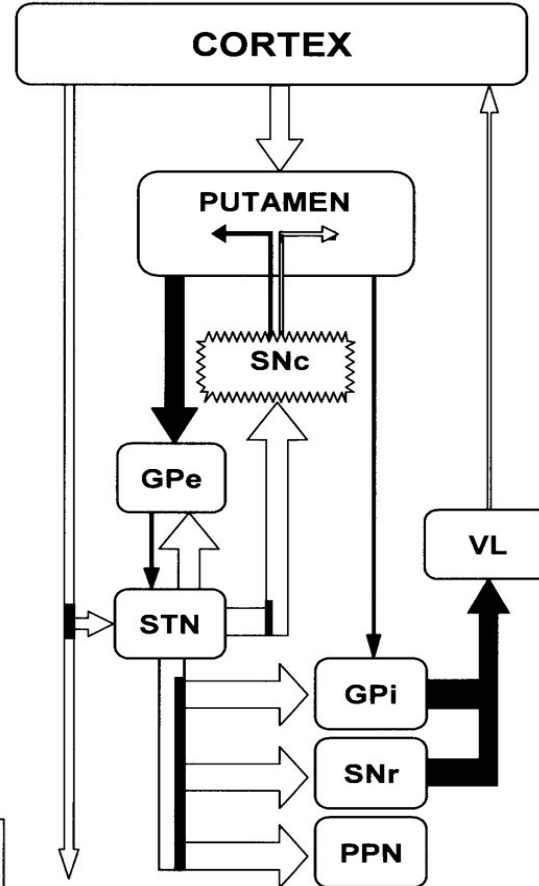
Diseases of the basal ganglia in human



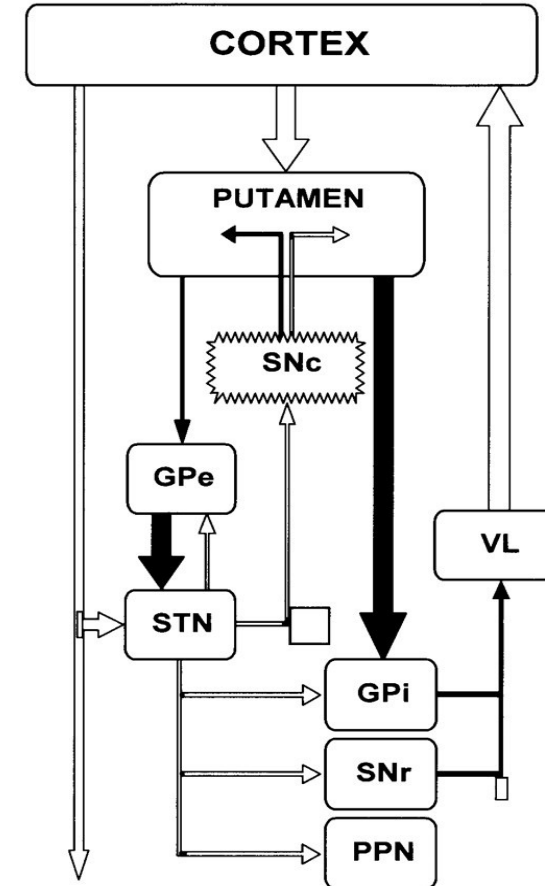
NORMAL MOTOR CIRCUIT



MOTOR CIRCUIT IN PD



CHOREA-BALLISM



https://www.researchgate.net/publication/232814482_Clinical_Features_Pathophysiology_and_Treatment_of_Levodopa-Induced_Dyskinesias_in_Parkinson%27s_Disease/figures?lo=1





Huntington's chorea:

a. is caused by a lesion in the posteroventral nucleus of the thalamus.

b. is caused by a lesion in the substantia nigra and globus pallidus.

c. is accompanied by kinetic tremors.

d. is accompanied by hypotonia

Lecture Quiz



The basal ganglia are primarily concerned with:

a.Tonic increased discharge in gamma efferent neurons.

b.Planning and programming of movements.

c.Performance of rapid alternating movements.

d.Maintenance of posture.

References



1. Guyton and Hall Textbook of Medical Physiology.

- <https://www.amazon.com/Guyton-Hall-Textbook-Medical-Physiology/dp/1455770051>

2. Ganong's Review of Medical Physiology, 25e.

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<https://www.amazon.com/Ganongs-Review-Medical-Physiology-Twenty-Fifth/dp/007182510X>

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*Thank
you*

